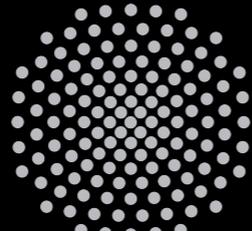
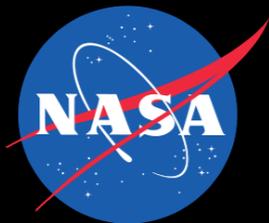
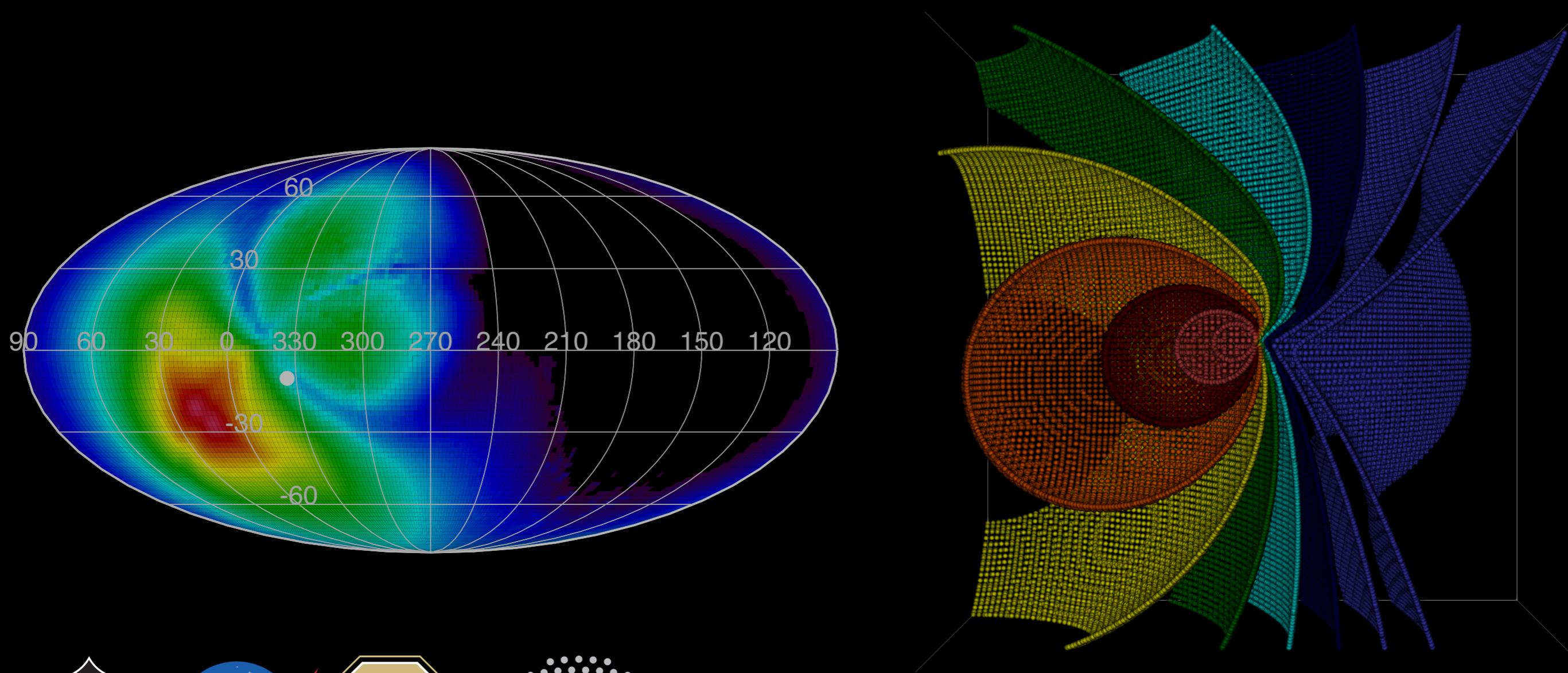


Impact Ejecta Environment of an Eccentric Asteroid: 3200 Phaethon

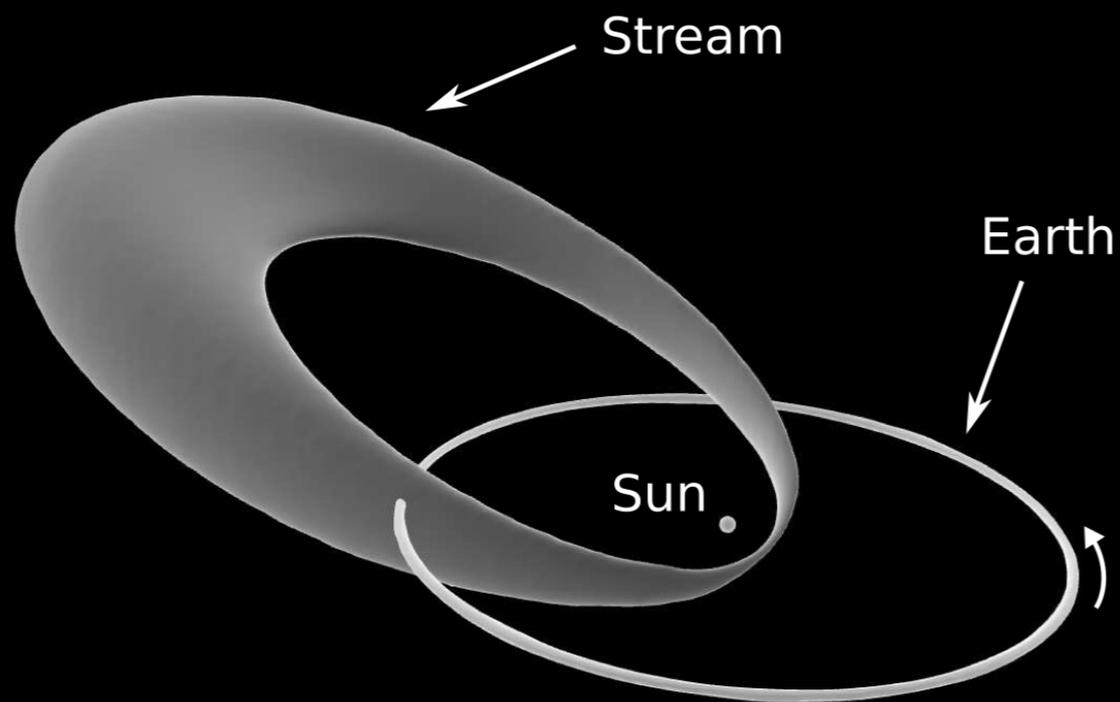
J. R. Szalay¹, P. Pokorný², M. Horányi³, D. Janches², M. Sarantos², R. Srama⁴

¹Princeton University, ²NASA/GSFC, ³University of Colorado Boulder, ⁴Universität Stuttgart



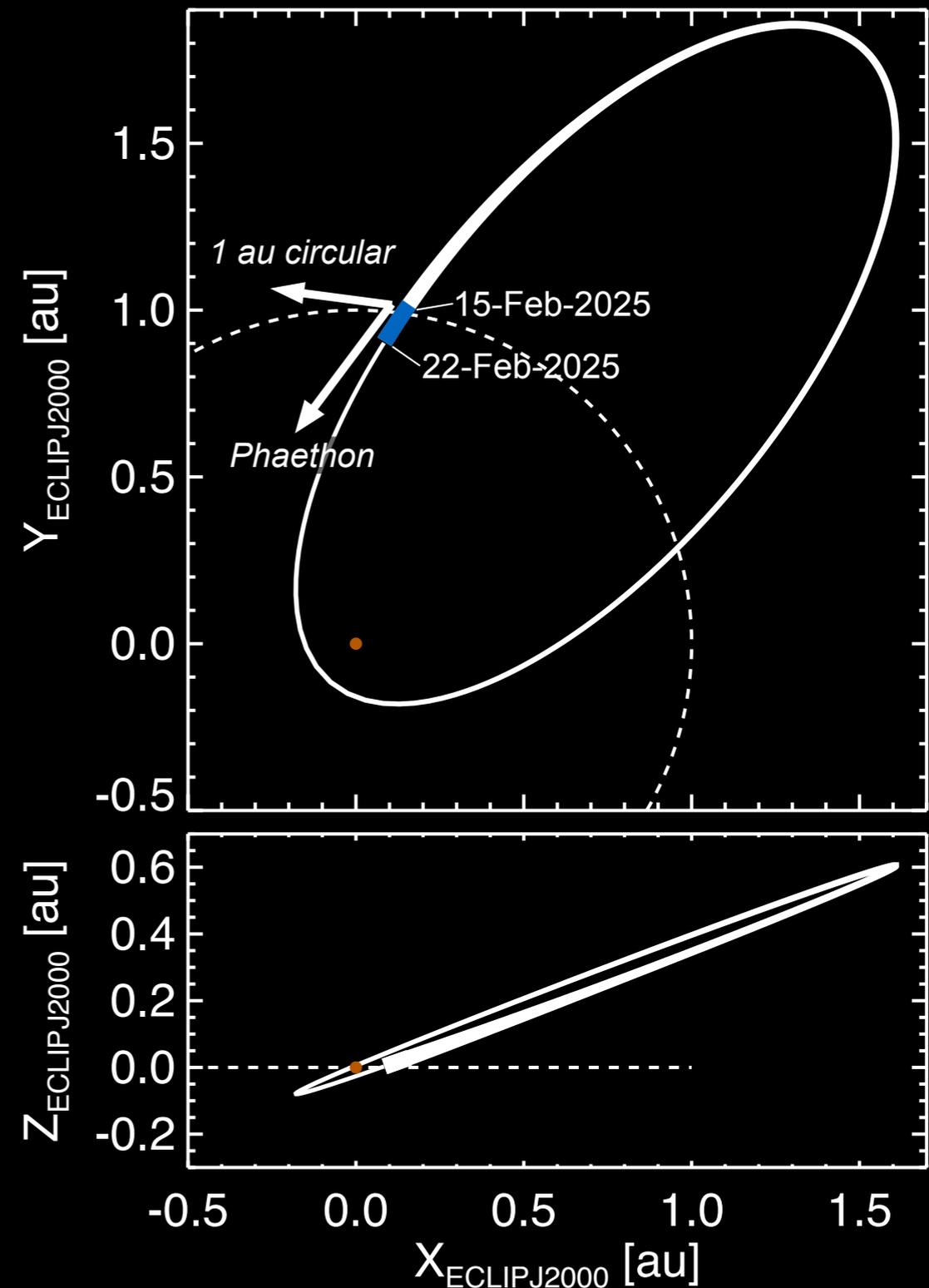
Asteroid (3200) Phaethon

- B-type Active Asteroid, $R_b \approx 3$ km
- Parent of Geminids meteor stream
- Target of JAXA's DESTINY+
 - Equipped with Dust Detector
 - Reveal regolith properties e.g. composition and impact yield



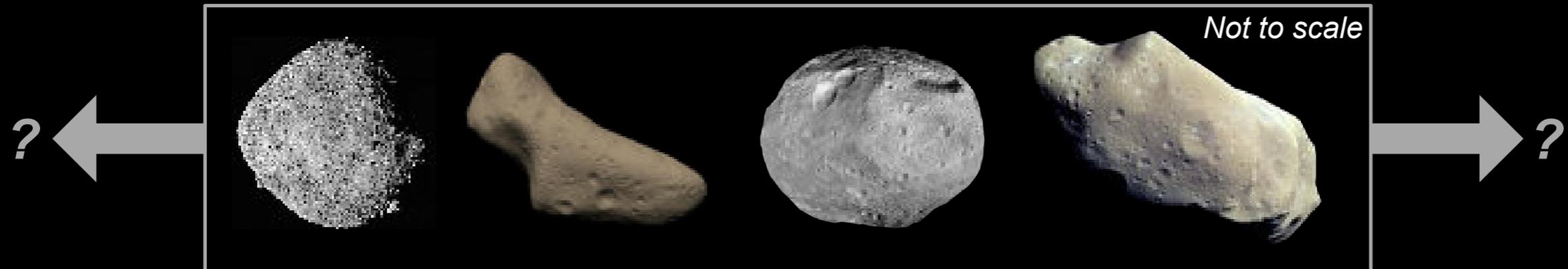
Barensten and Lefevre, 2006

$$a=1.27 \text{ au}, e=0.89, i=22^\circ$$



Impact Ejecta Yield for Asteroids Largely Unconstrained

Asteroids



Moon



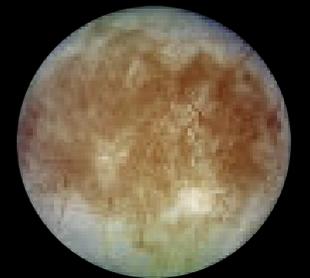
Callisto



Ganymede



Europa



10^1

10^2

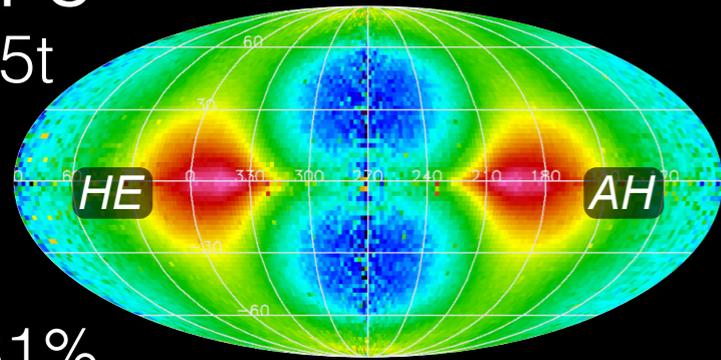
10^3

10^4

Ejecta Mass / Impactor Mass

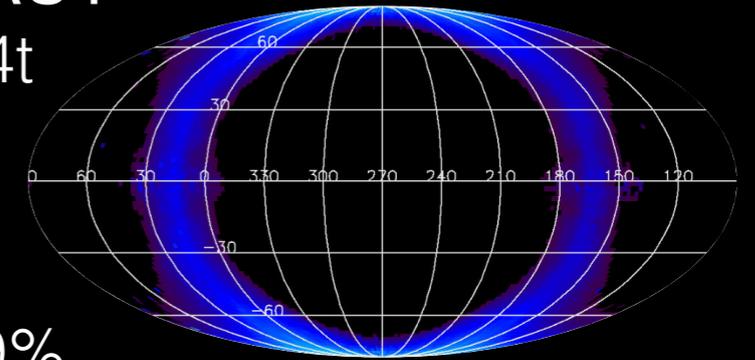
Meteoroid Environment at 1 au - Windshield View

JFC
35t



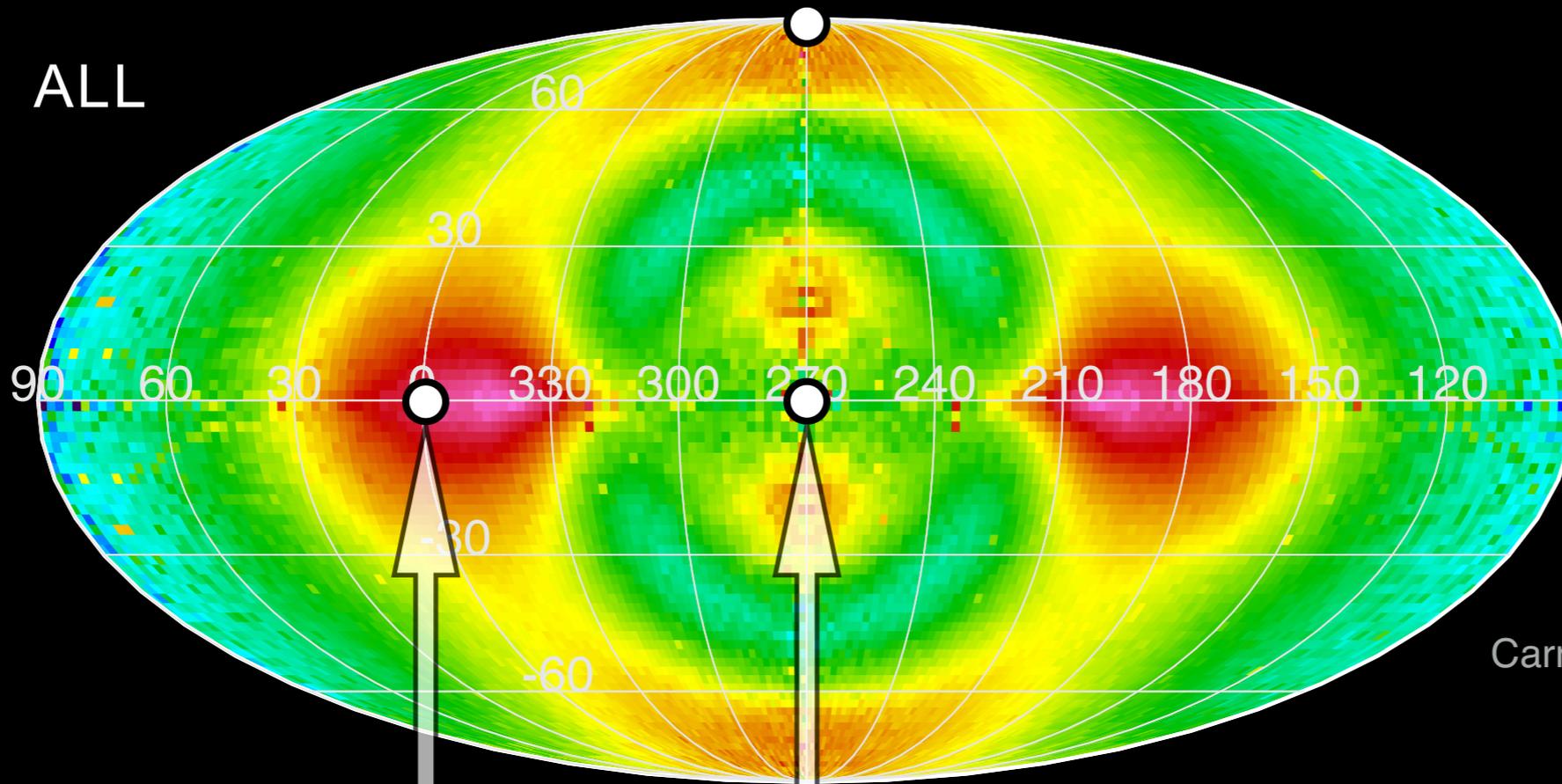
81%

AST
4t



9%

ALL

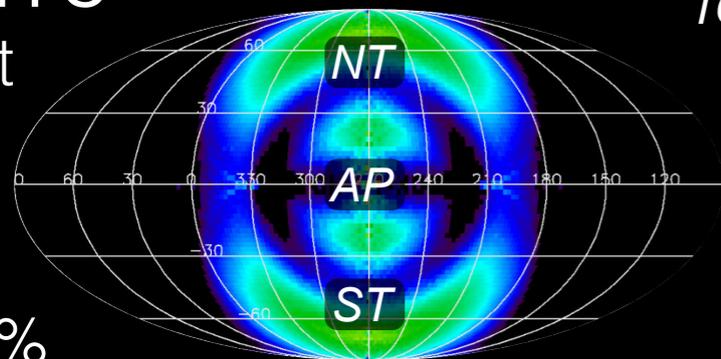


ECLIPJ2000 +z

43 tons/day

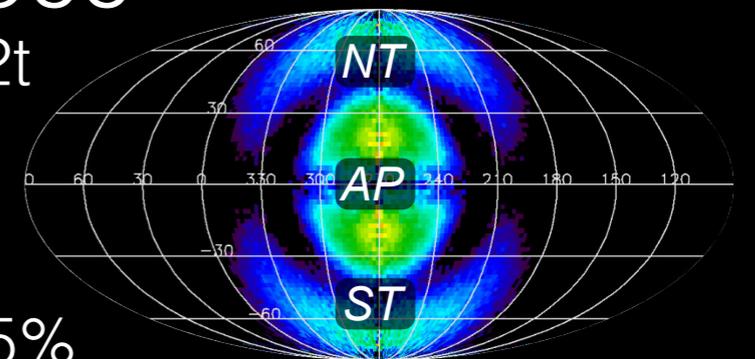
Carrillo-Sanchez et al. 2016

HTC
3t



7%

OCC
2t



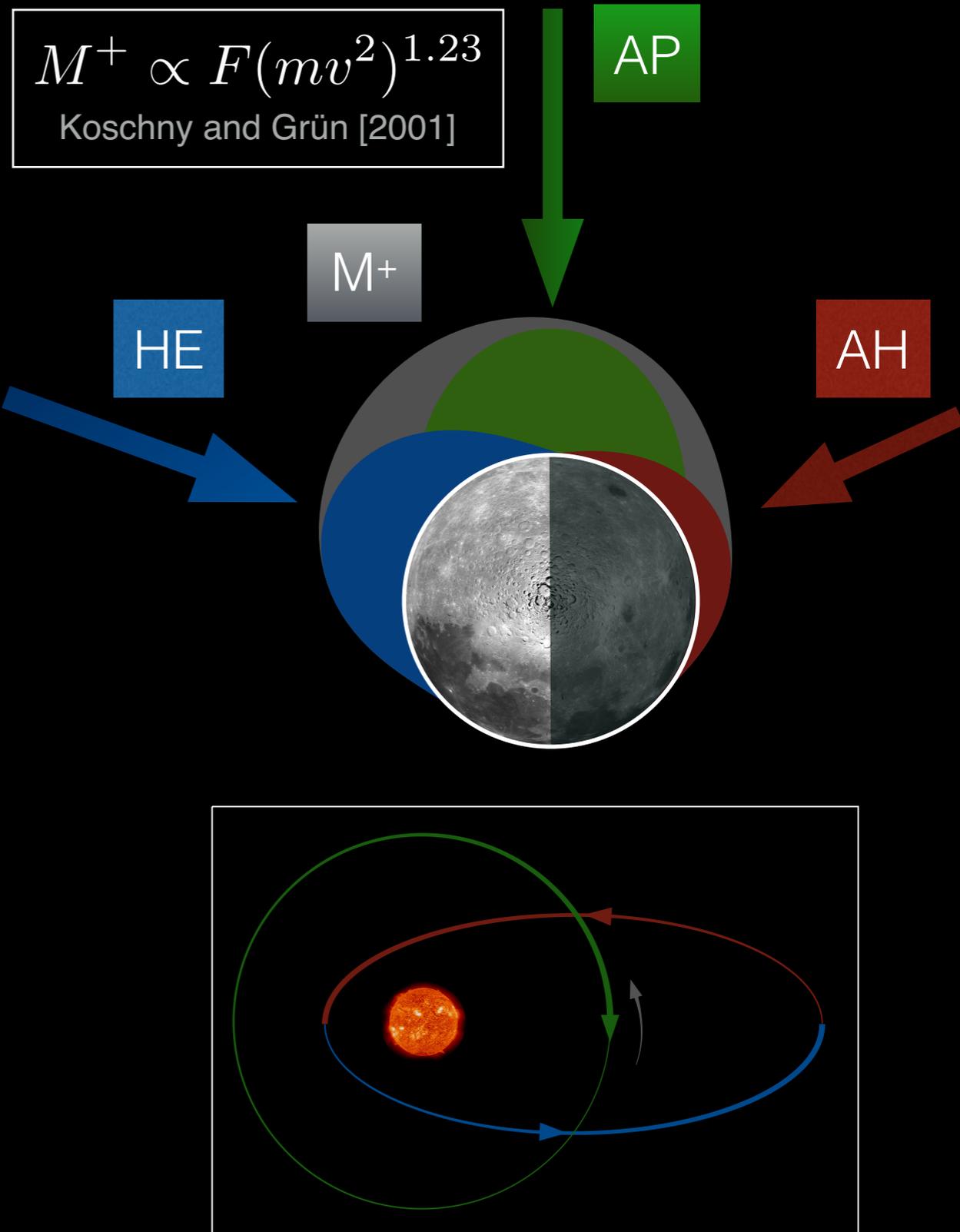
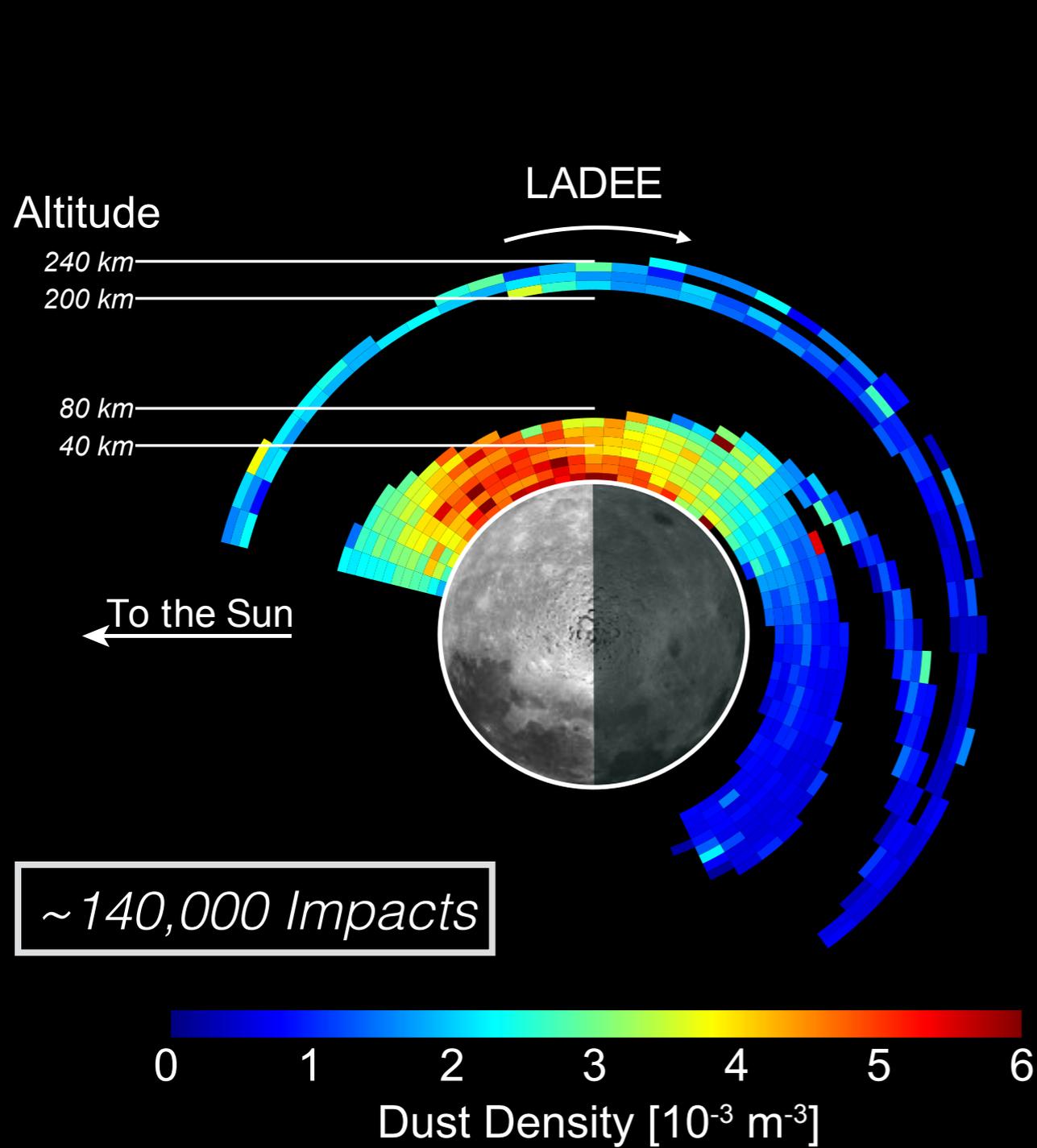
5%



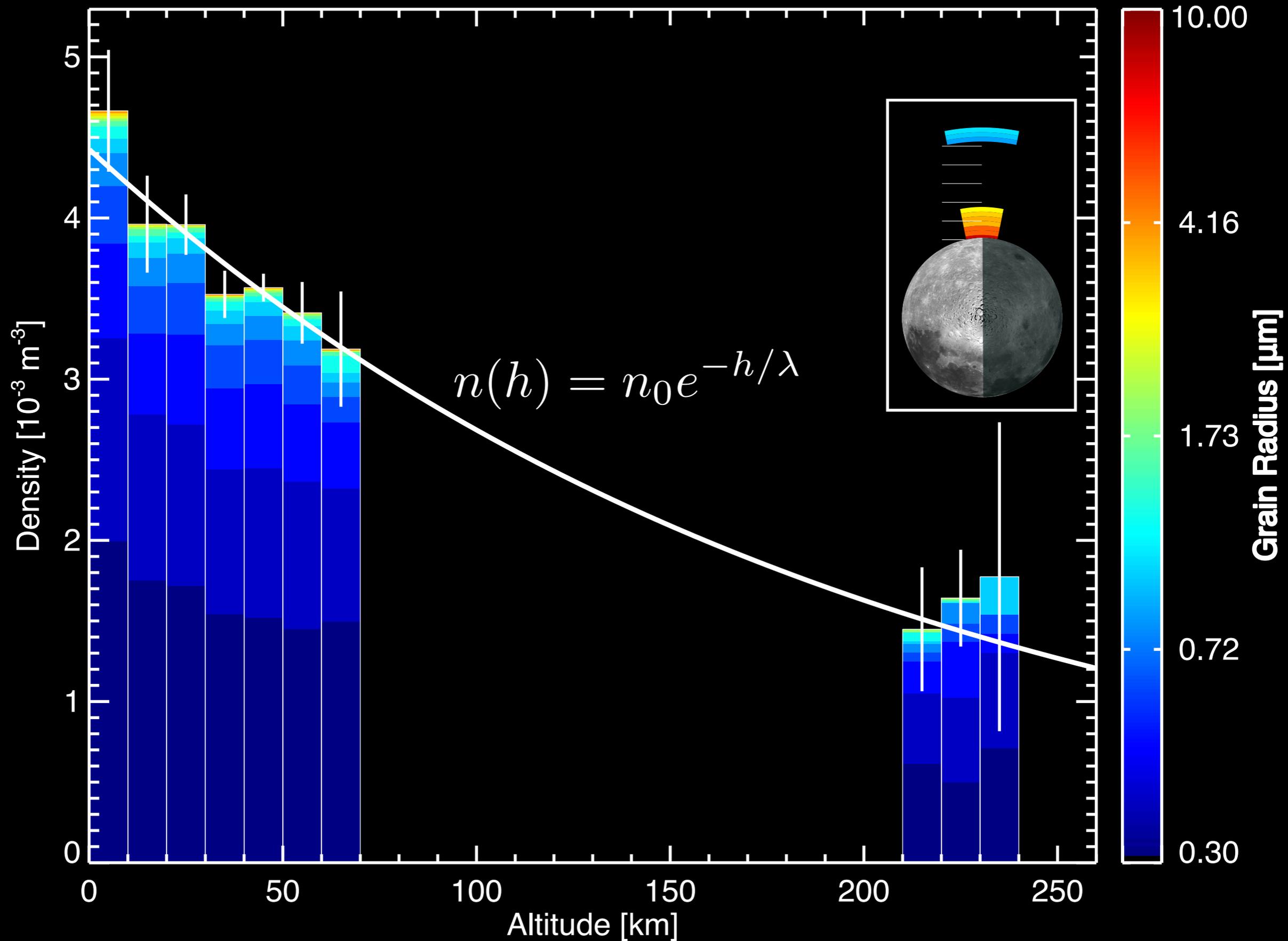
To Sun

Apex (circular)

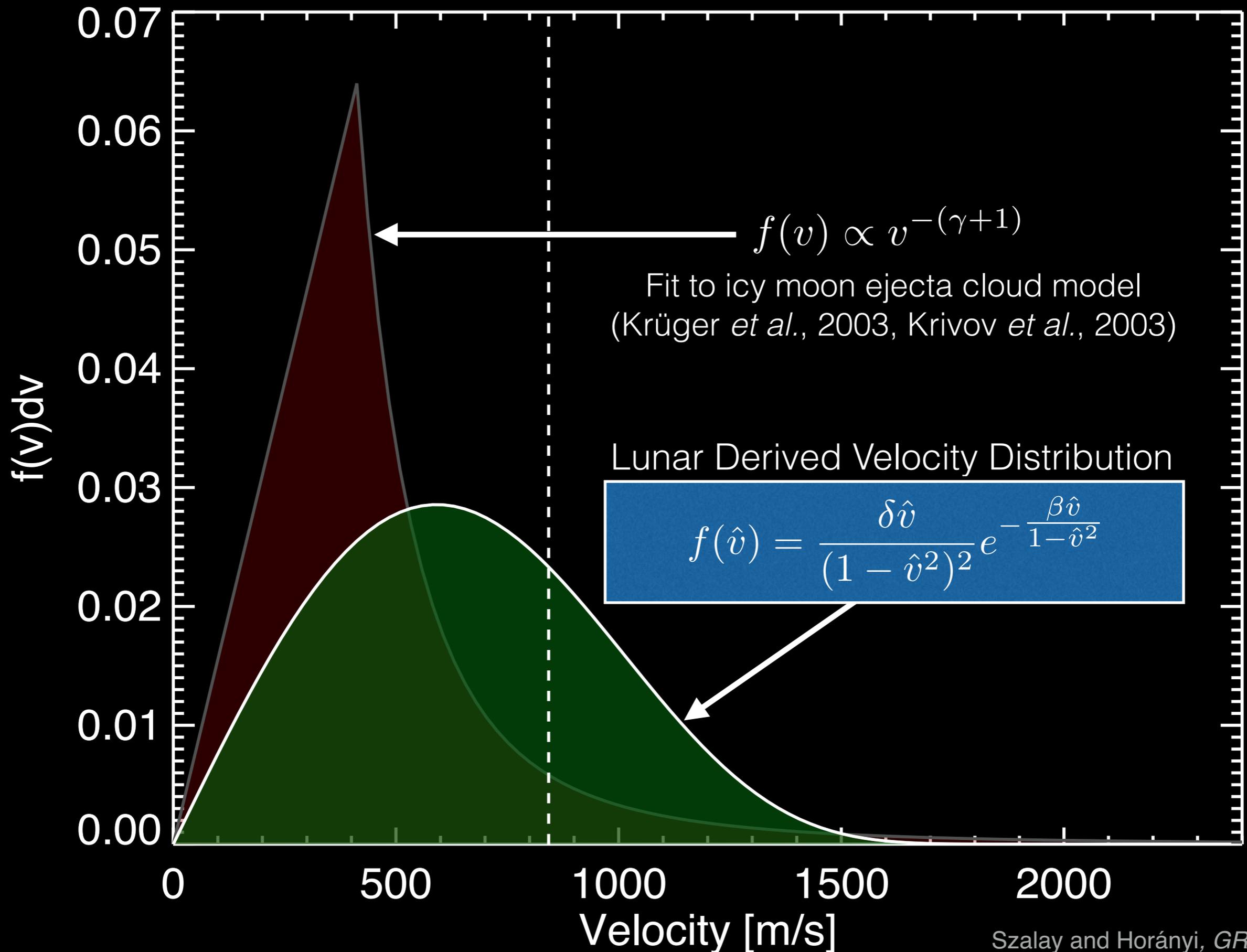
Structure of the Lunar Dust Cloud



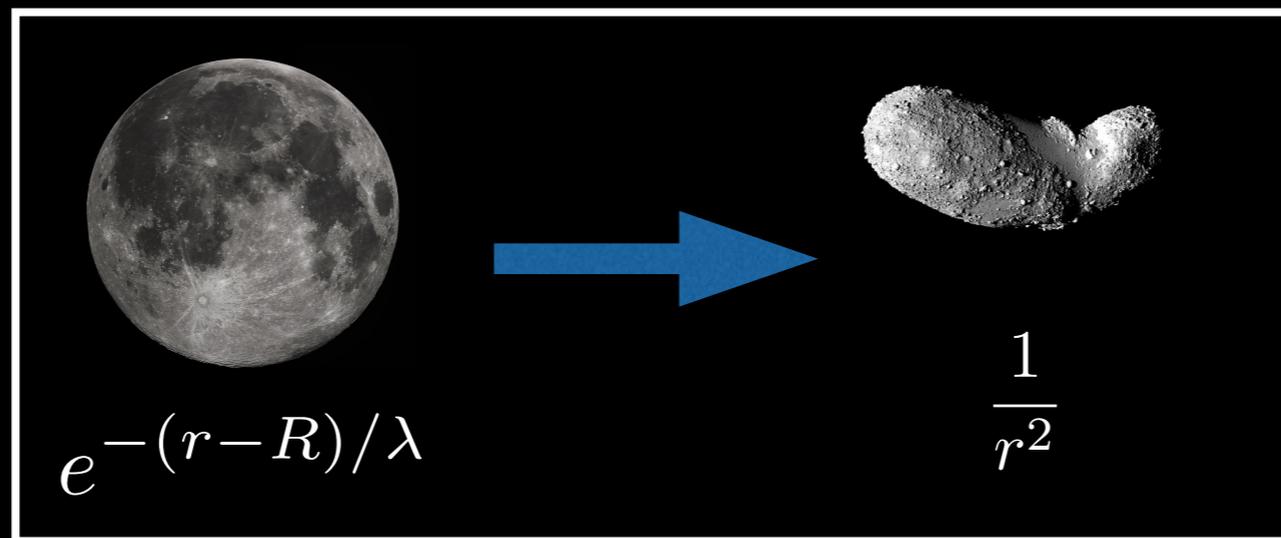
Altitude Dependence



Velocity Distribution Function



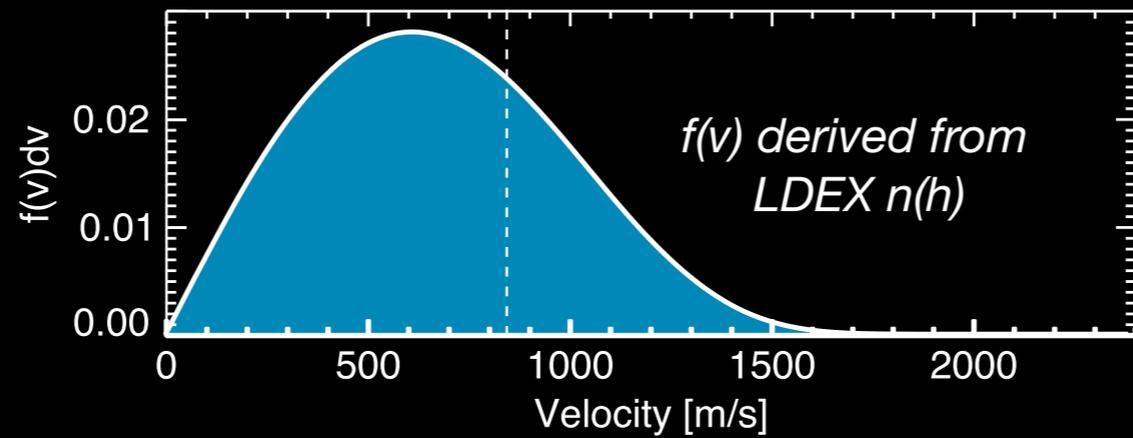
Extending Lunar Ejecta Measurements to Asteroids



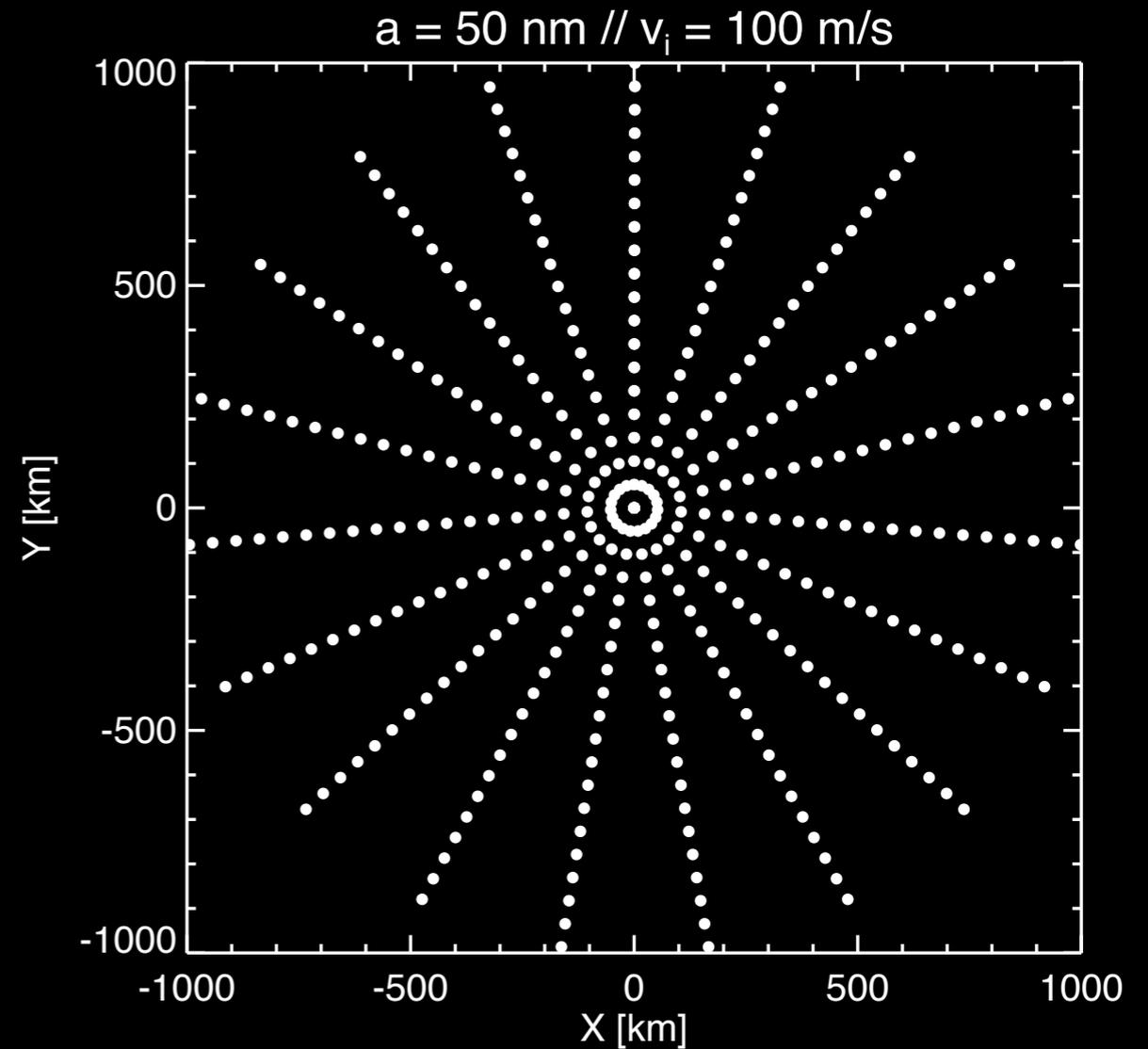
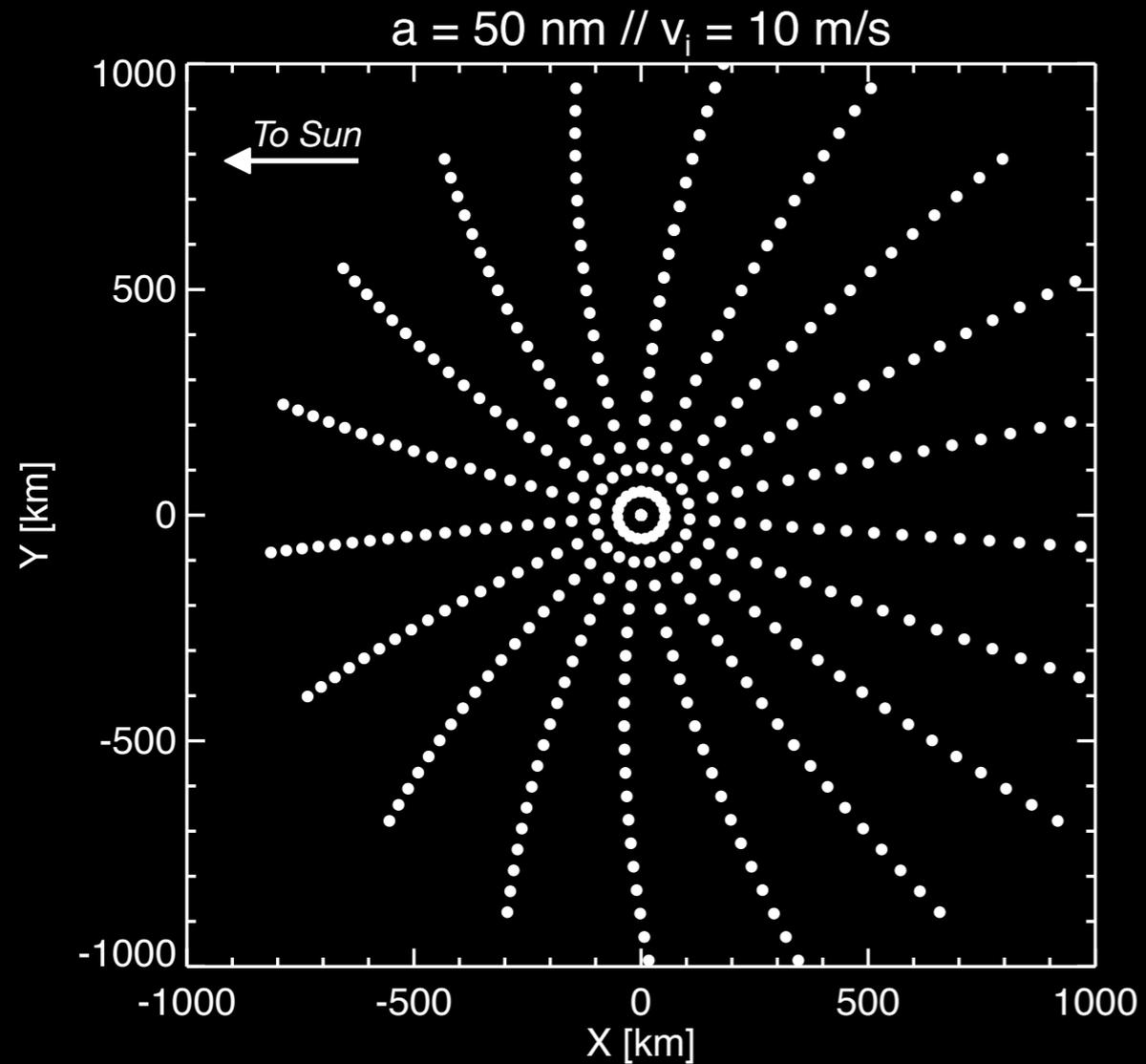
Assumptions

- Ejecta production is identical to the Moon
- $M^+ \propto F(mv^2)^{1.23}$ (Koschny and Grün, 2001)
- $f(> m) \propto m^{-0.9}$ and extends to $a > 50$ nm
- Grain density of 2.5 g/cc
- Gravity is negligible (all ejecta unbound)
- Radiation pressure negligible for $a > 50$ nm

Effects of Radiation Pressure (1 AU)

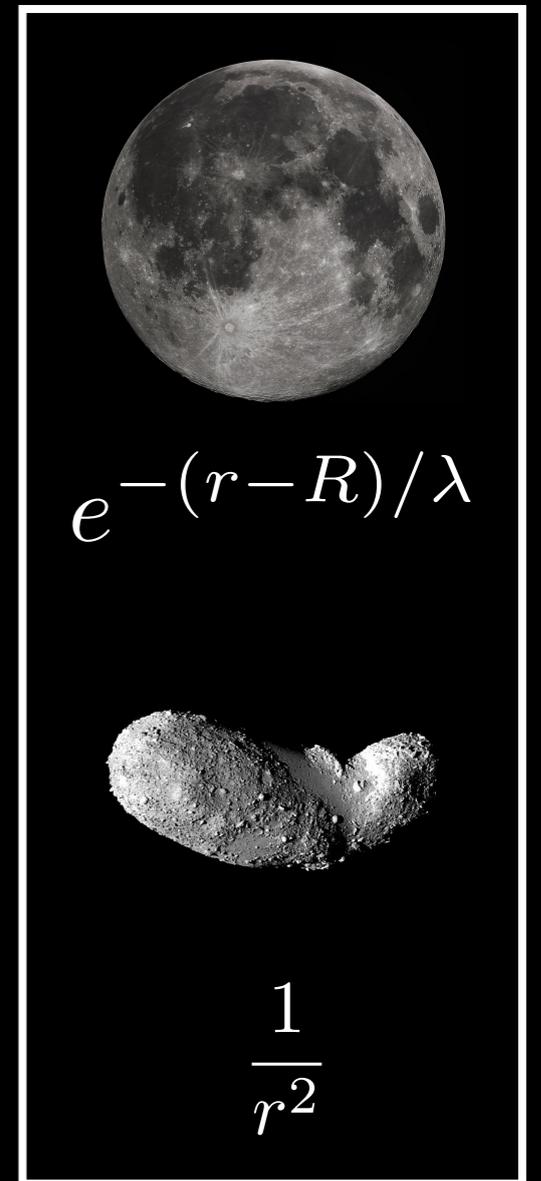
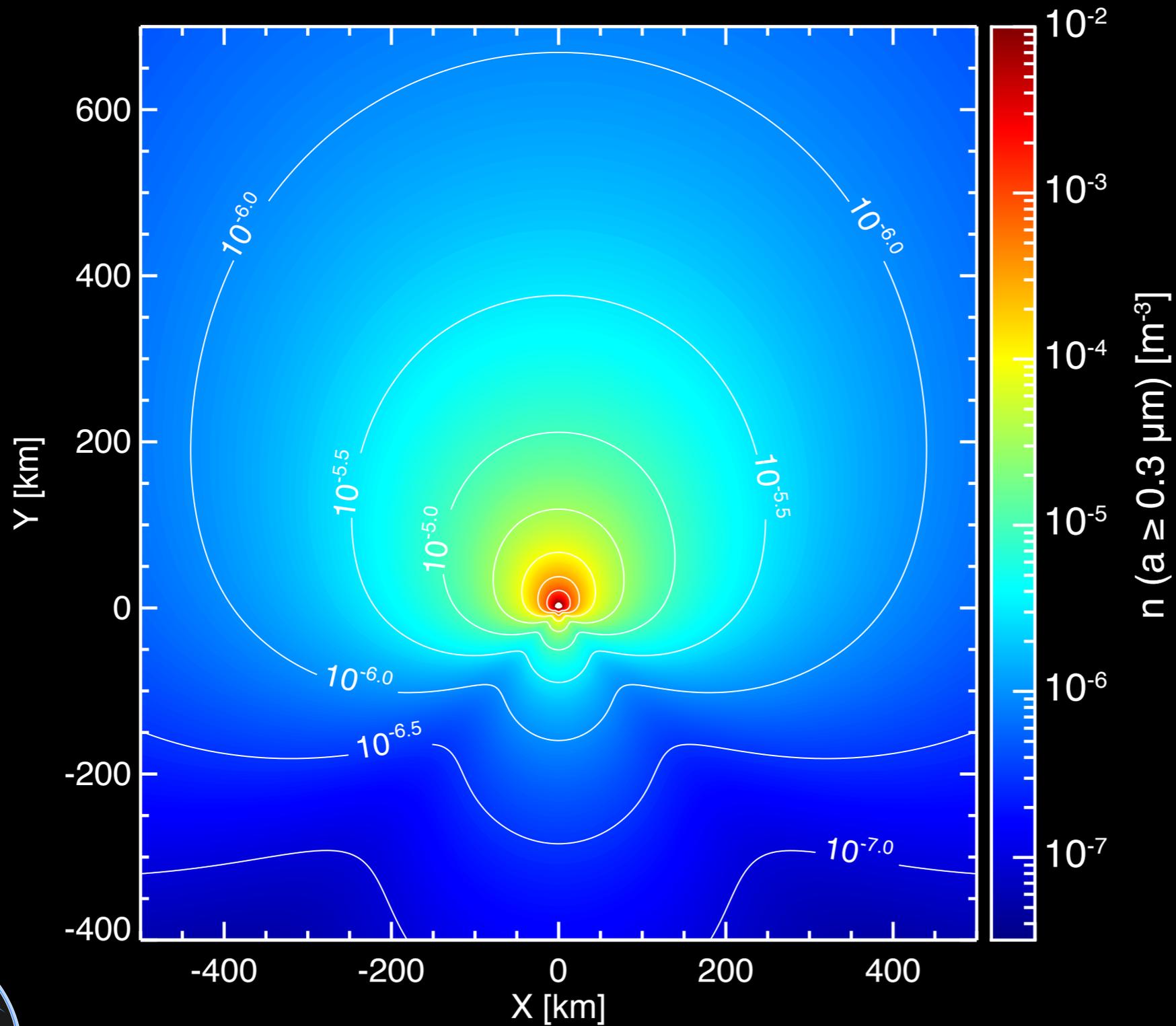


$$\ddot{x} = \frac{C}{2a\rho d^2}$$

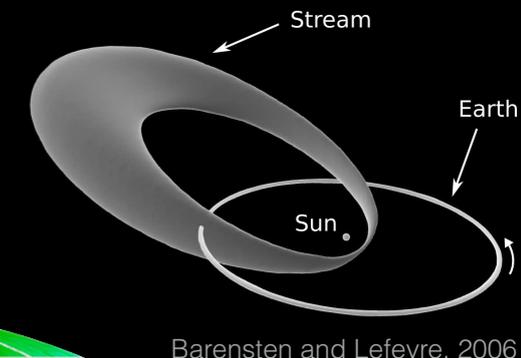


Radiation Pressure is negligible for 50 nm grains in these models

NEA Dust Distribution (1 au circular)

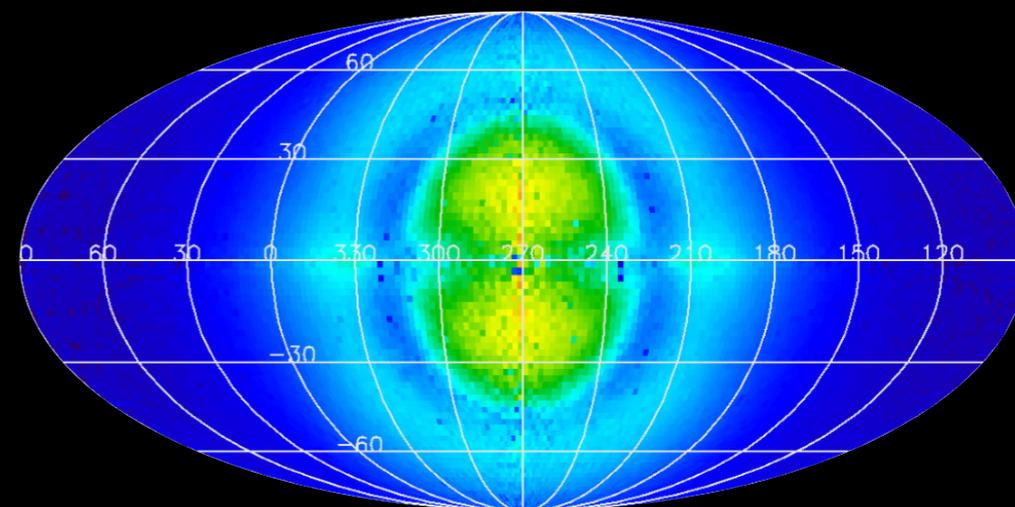
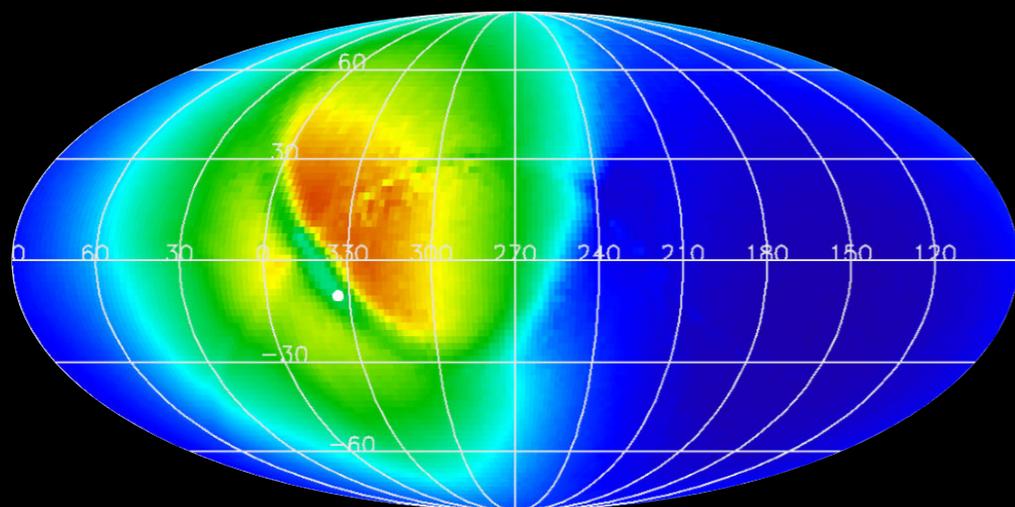
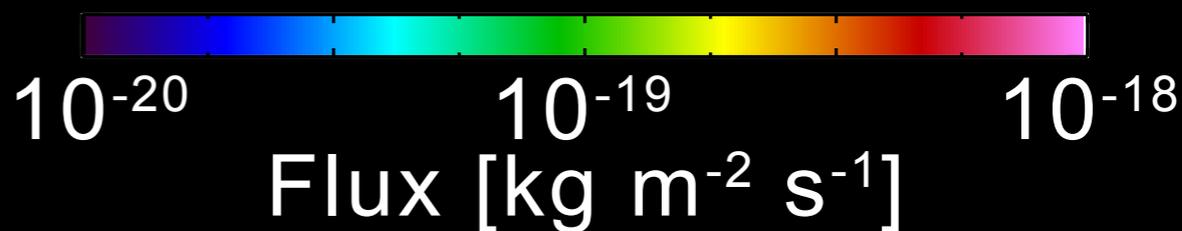
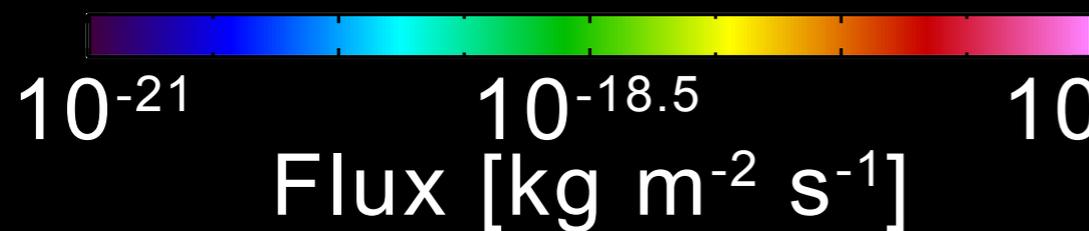
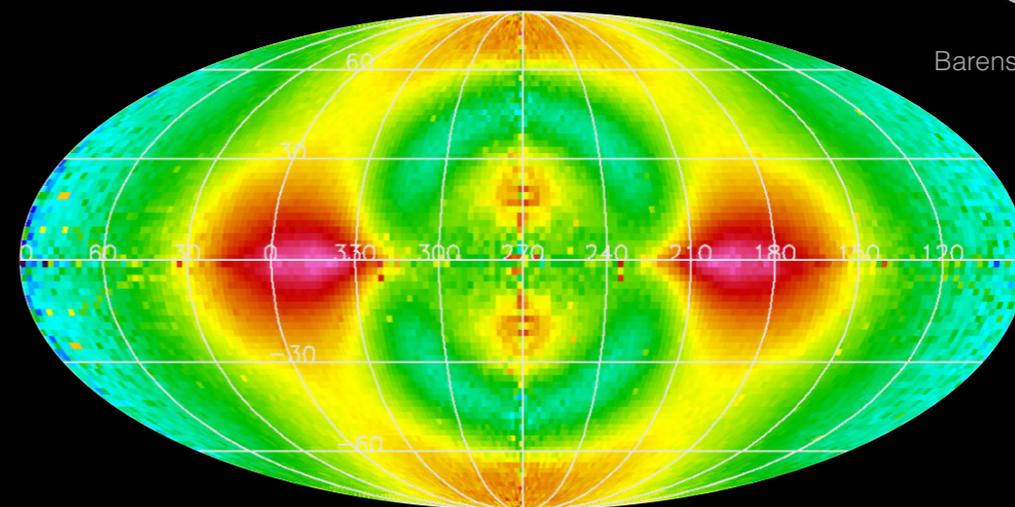
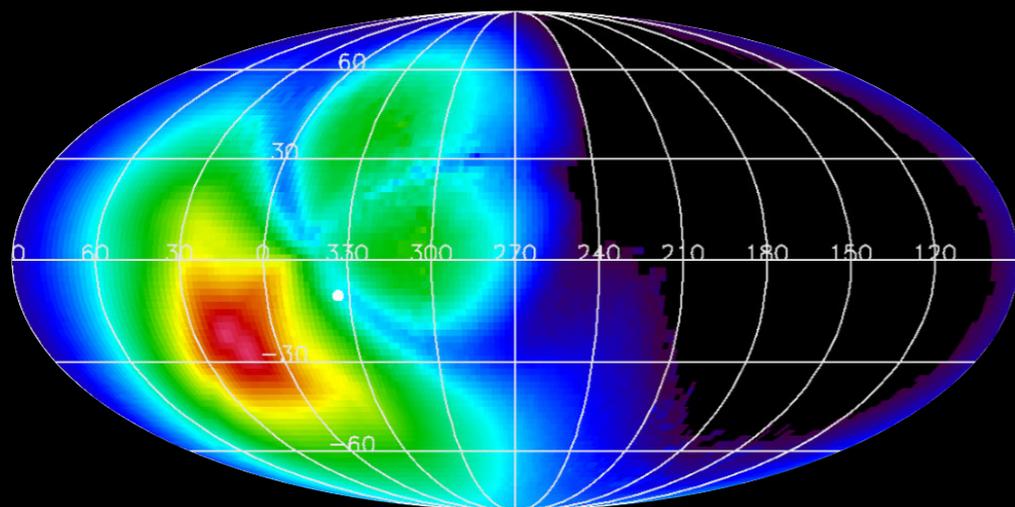


Phaethon Impact Flux at 1 au



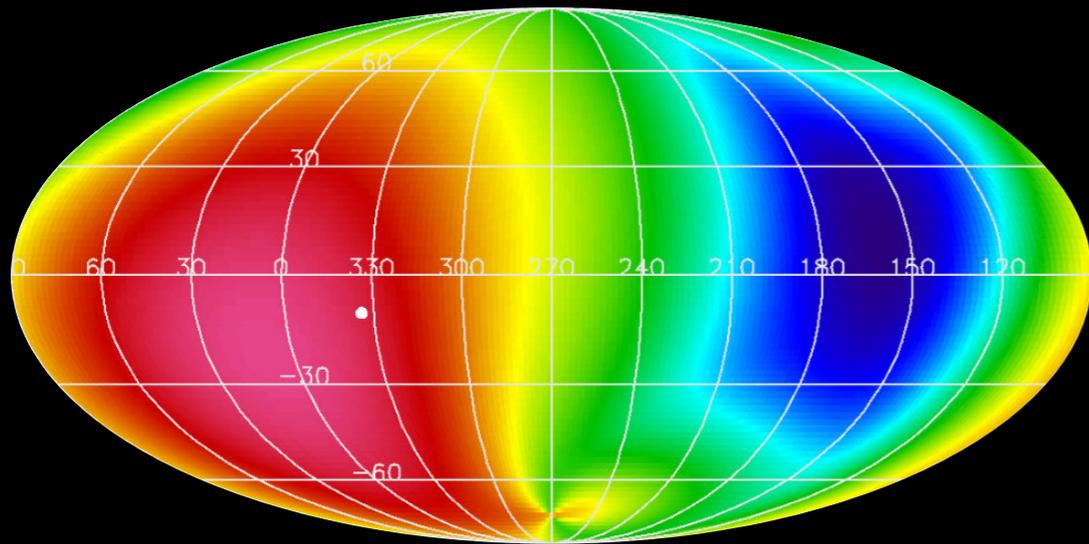
Phaethon

1 au circular

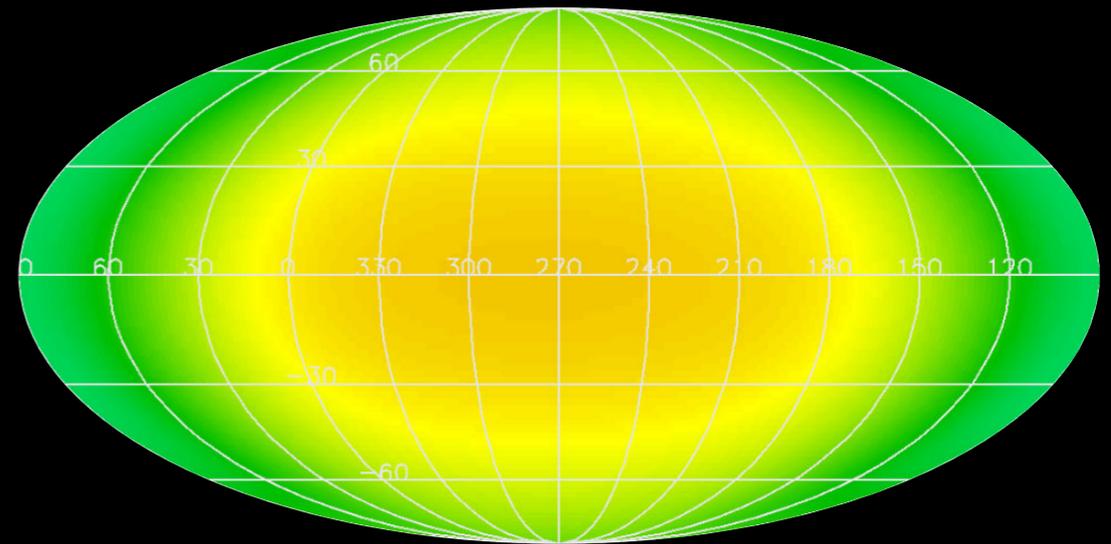


Phaethon Ejecta Density at 1 au

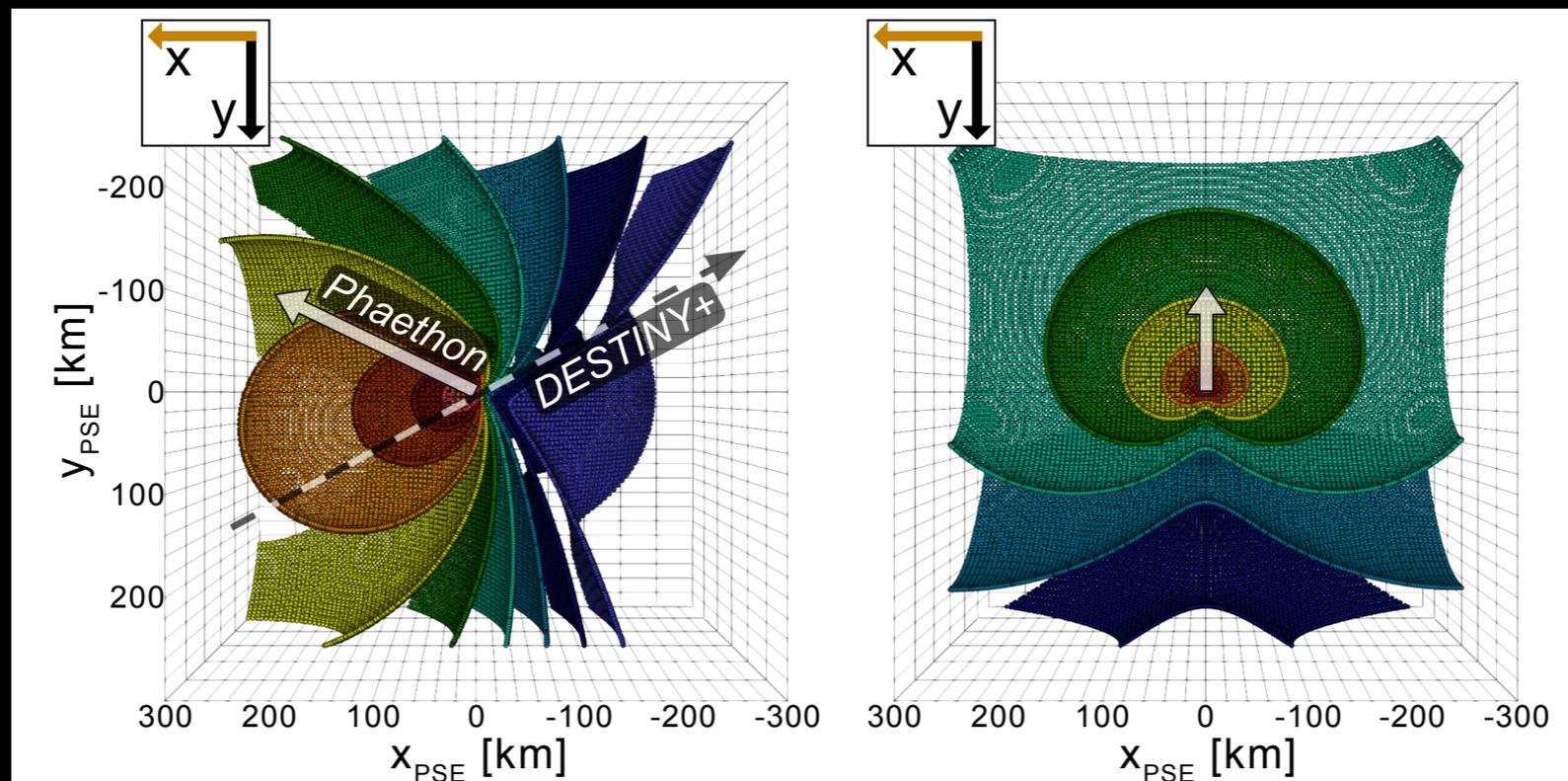
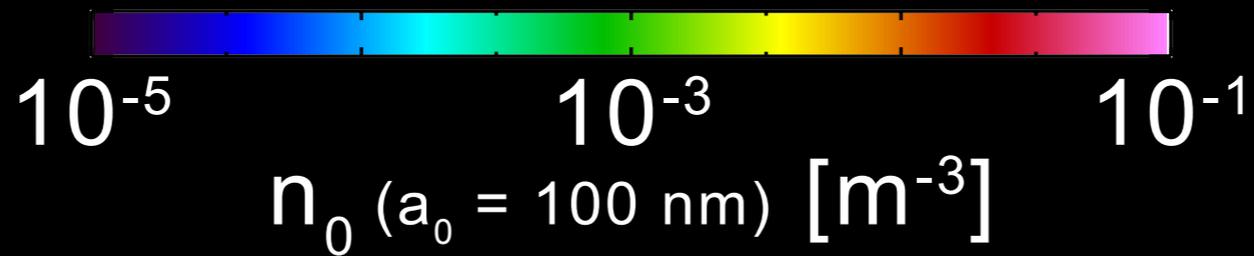
Phaethon



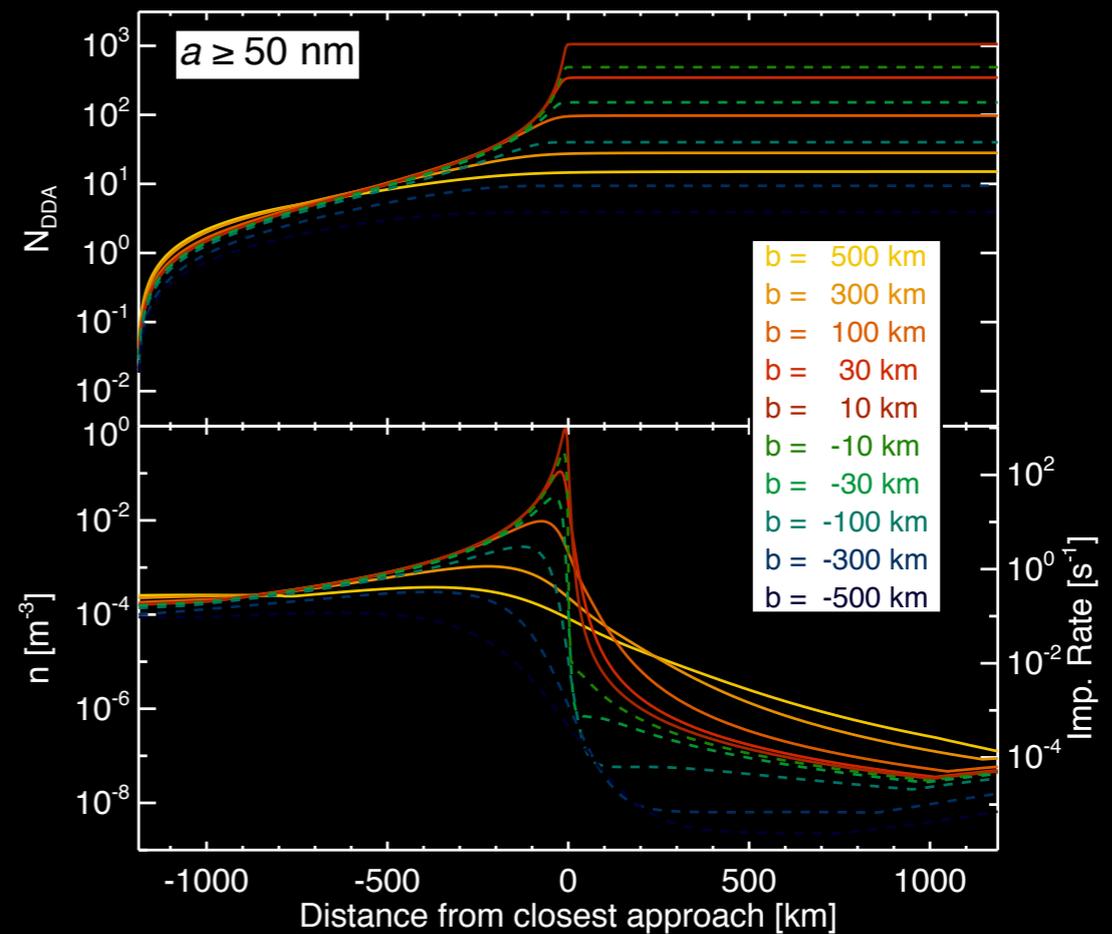
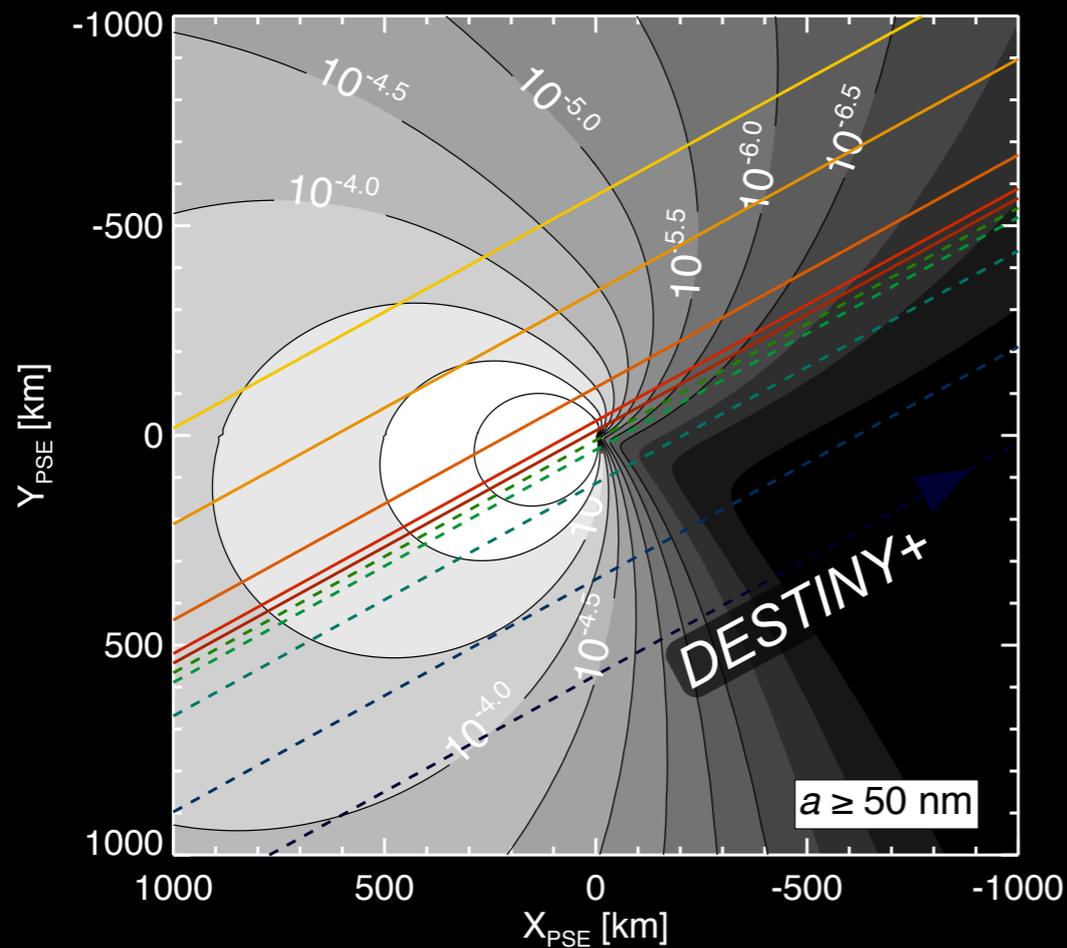
1 au circular



$$M^+ \propto F(mv^2)^{1.23}$$



Destiny+ Predictions

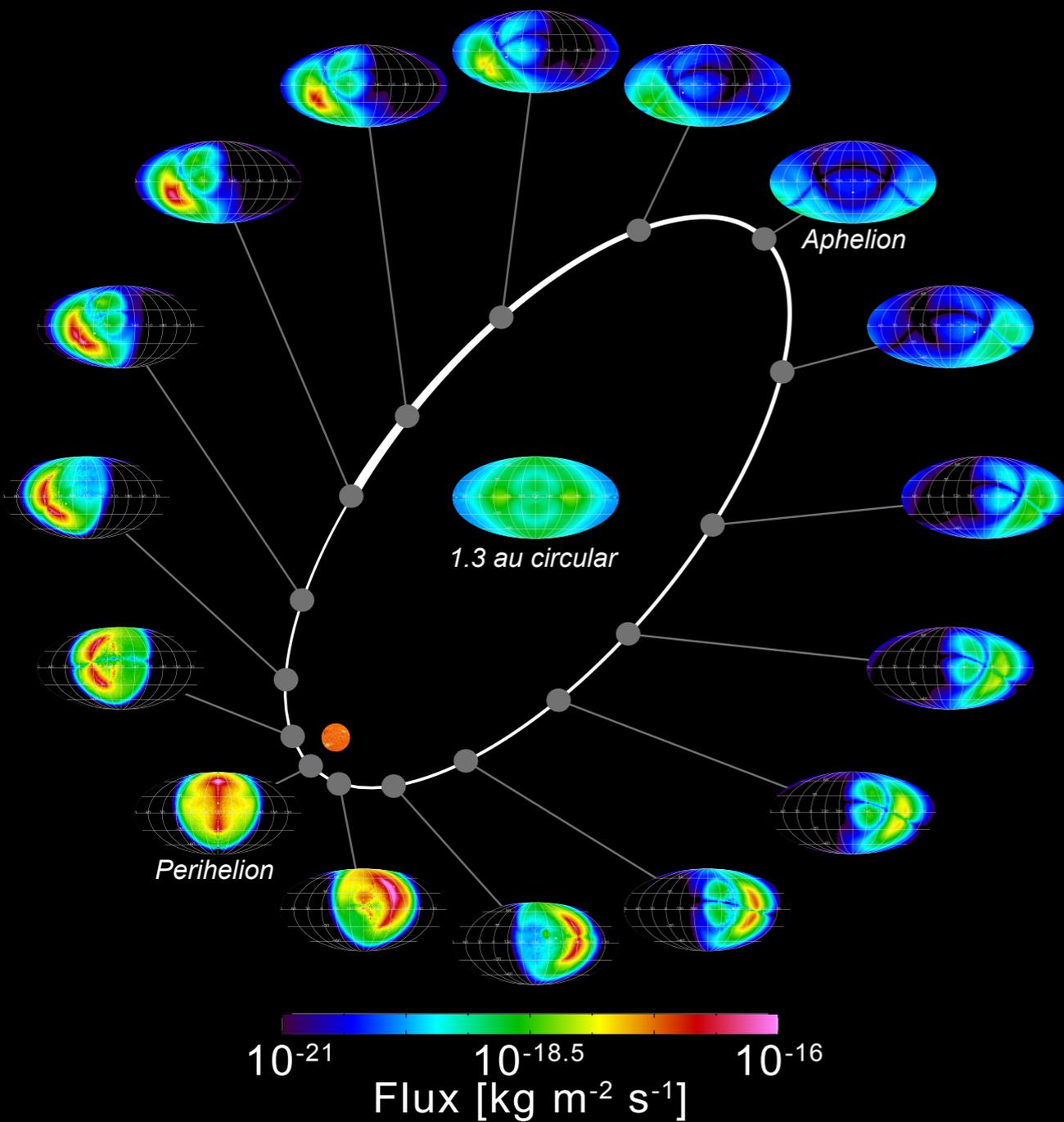


Destiny+ DDA Expected Total Counts

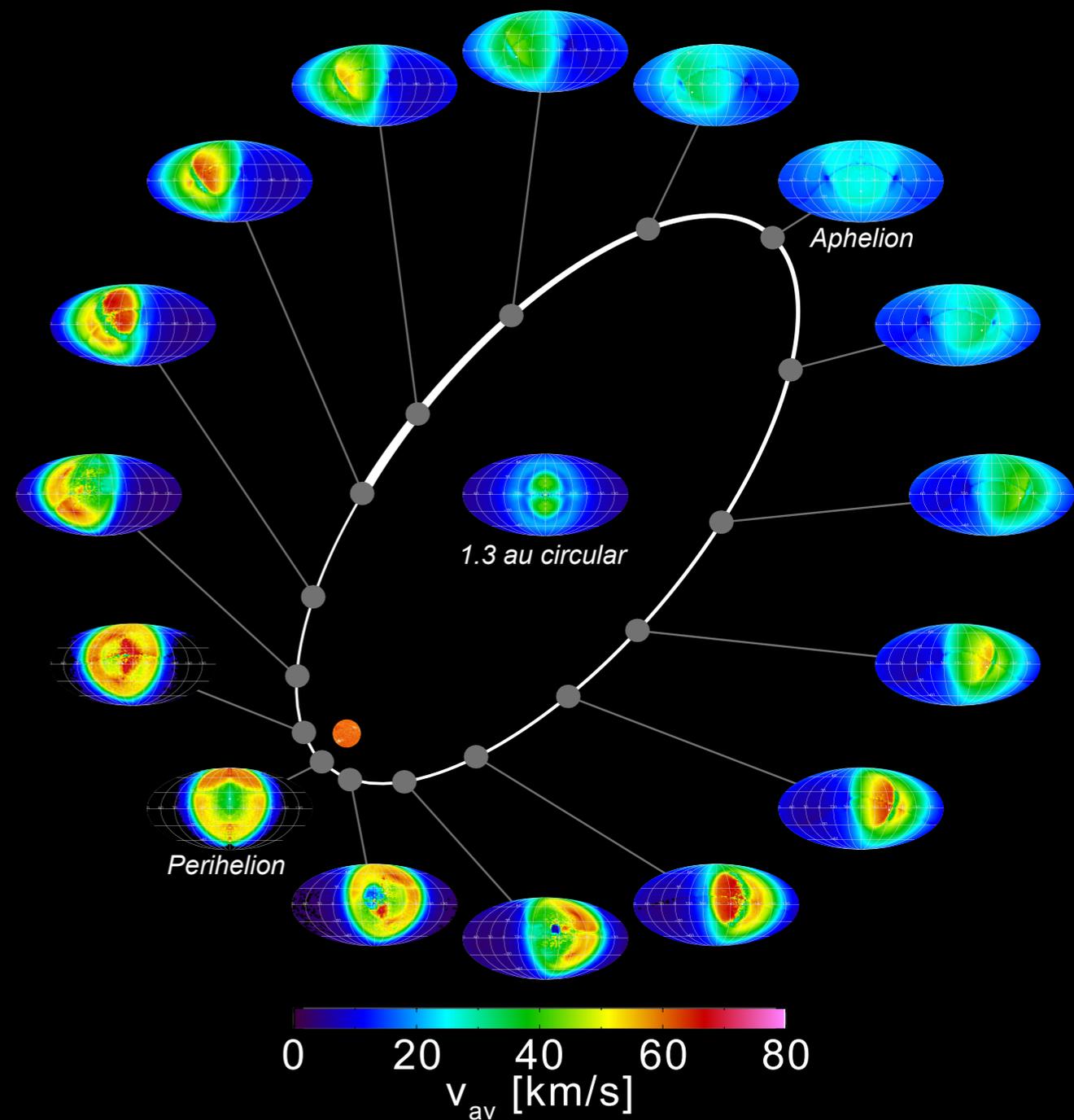
(22-Feb-2025)	100 km	300 km	500 km
a > 50 nm	97 (40)	28 (9)	15 (4)
a > 100 nm	15 (6)	4 (1)	2 (1)
a > 300 nm	1 (0)	0	0

Orbital Evolution of Impact Ejecta

IDP Flux

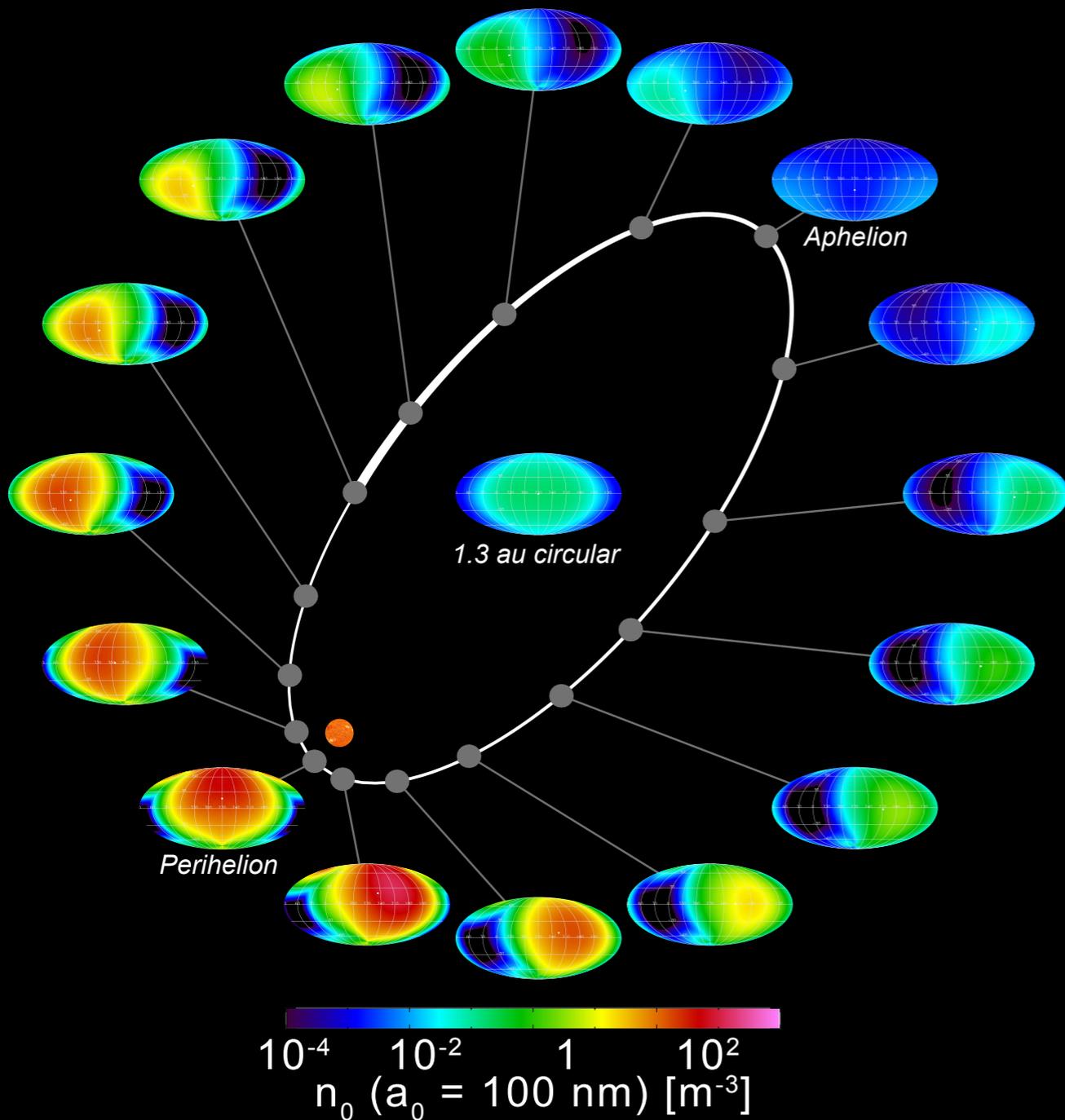


IDP Average Impact Speed

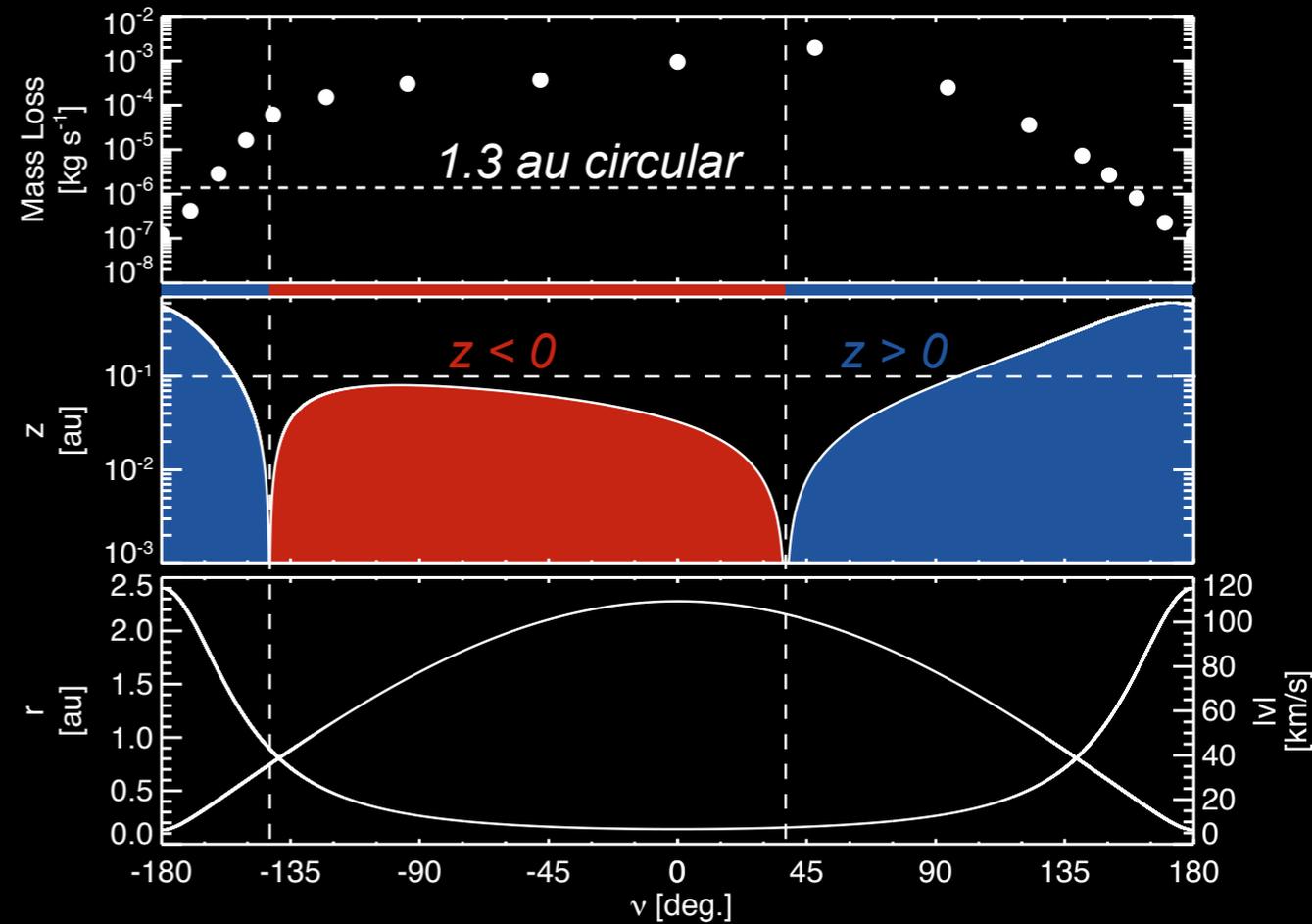


Orbital Evolution of Impact Ejecta

Impact Ejecta Density



$$\langle \dot{M}_{pha} \rangle \approx 4 \times 10^{-5} \text{ kg/s} \approx 40 \dot{M}_{cir}$$



Erosion Rates

Phaethon	200 μm / 10^6 years
Circular	6 μm / 10^6 years

Conclusions

- Phaethon's ejecta cloud is highly asymmetric near 1 au, caused dominantly by helion JFC IDPs on ascending arcs.
- Phaethon sheds $\sim 40x$ more material from impact bombardment than an equivalent circular orbiting body. Provides context for asteroidal space weathering. Not sufficient to source the Geminids.
- DESTINY+ could expect at least 100 impacts for $a > 50$ nm at 100 km flyby altitude. Total counts scale as $\sim 1/h$. Higher rates for larger yield.
- DESTINY+ will reveal asteroidal impact yield, regolith composition, and test our models of the zodiacal dust cloud